Low Intensity High Temperature (LIHT) Solar Cells for Venus Exploration Mission

Completed Technology Project (2017 - 2019)

Project Introduction

Venus aerial and surface missions require solar cells capable of operating at high temperature and low solar intensities for long periods of time. Currently, these missions are considering the use of primary batteries. However, these batteries can only enable few hours of operation. State of Practice (SOP) solar cells are not suitable for operation at high temperature because of the problems associated with semiconductor materials and contact materials. We are proposing an innovative approach to develop high temperature solar cells for future Venus exploration missions. The overall objective is to develop Low Intensity High Temperature (LIHT) solar cells that can function and operate effectively in the Venus atmosphere at various altitudes, and survive on the surface of Venus where the temperature reaches 450-500°C. The specific objective of year 1 is to develop critical high temperature solar cell components such as cell electrical contact materials and optimize cell designs to enable solar cells to function effectively for long duration in Venus environments. Successful completion of this year 1 effort will result in demonstrating the technical feasibility of the proposed project. The specific objective of the year 2 effort is to fabricate optimized LIHT solar cells and demonstrate efficiency and life time performance targets under simulated Venus conditions. We propose to develop a dual junction GaAs/GaInP solar cell for future Venus exploration. The novel features of the proposed cell include: a) high bandgap semiconductor materials (GaAs/GaInP), that are optimized to capture solar irradiance efficiently at Venus, b) high temperature tunnel junctions, c) high temperature solar cell contacts, d) anti-reflection coatings, and e) Al2O3 corrosion protection coatings. This new, advanced LIHT cell will capture the red-shifted peak of the Venus spectrum in the GaInP layer and the remaining longer wavelengths in the GaAs layer. Layers will also be current matched by simple layer thickness modifications to optimally capture the full Venus solar spectrum. This cell will also demonstrate more robust, high temperature electrical contacts. For this task, we have assembled a multidisciplinary team from Caltech, MicroLink Devices Inc. and JPL to develop the proposed LIHT solar cells required for future Venus exploration missions. MicroLink was involved in the development of dual junction GaAs/GaInP high temperature solar cells required for terrestrial applications under ARPA-E's Full-Spectrum Optimized Conversion and Utilization of Sunlight (FOCUS) program. Within the FOCUS program, MicroLink has developed several materials and component technologies that improve high temperature cell performance and this includes: 1) high bandgap semiconductor materials with high temperature resistant dopants, 2) tunnel junction to enable stable operation at high temperature, 3) antireflection coatings, and 4) novel cell design. The cells developed so far operated efficiently at room temperature but performed poorly at high temperatures due to problems associated with solar cell contact materials. Further, these cells cannot function effectively at low solar intensities and corrosive environments encountered in the mid- low altitudes of the Venus atmosphere. The critical modifications required to improve the high temperature operation of the 2J cells above 400°C include

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Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Responsible Program:

Hot Operating Temperature Technology

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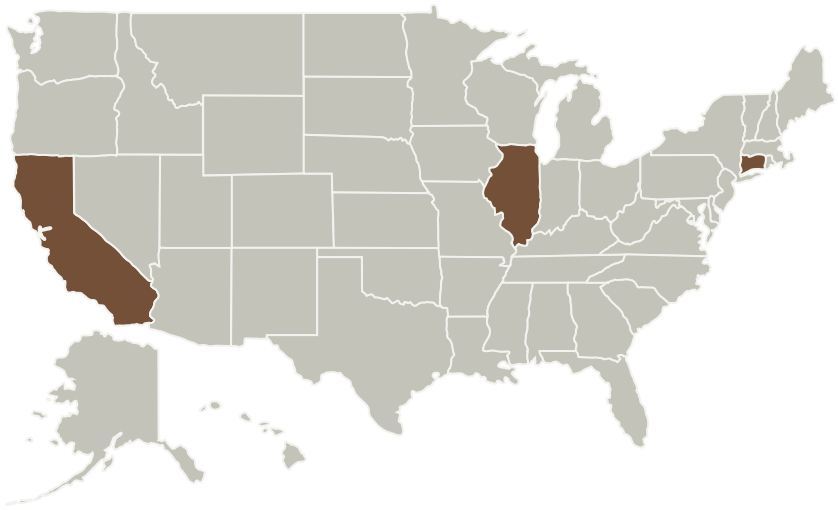
replacing current cell contact materials with high temperature stable Ohmic contacts. The overall technical approach consists of: a) selection of high temperature contact materials to improve the performance of dual junction GaAs/GaInP solar cells at high temperature, b) optimization of cell designs to enhance performance under Venus solar spectrum and environmental conditions and c) use of Al2O3 coating to protect cells from corrosion.

Anticipated Benefits

Successful completion of this project will result in the development of high temperature solar cells required to enable long-duration variable altitude (mid-low) aerial missions at Venus. Further development of these cells in the future may also result in the development of second generation high temperature solar cells that will enable long duration Venus surface exploration missions.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
California Institute of Technology(CalTech)	Supporting Organization	Academia	Pasadena, California

Project Management

Program Director:

Carolyn R Mercer

Program Manager:

Quang-viet Nguyen

Principal Investigator:

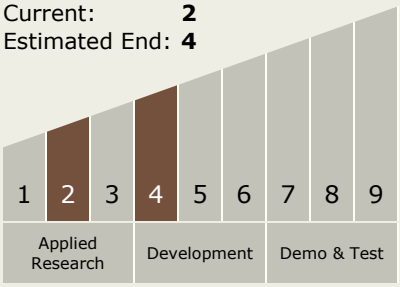
Jonathan Grandidier

Co-Investigators:

James A Cutts
Alex Kirk
Mark Osowski
Karl Y Yee
Minjoo L Lee
Karen R Piggee
Harry A Atwater

Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **4**



Technology Areas

Primary:

- TX03 Aerospace Power and Energy Storage
  - TX03.1 Power Generation and Energy Conversion

Continued on following page.

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Primary U.S. Work Locations	
California	Connecticut
Illinois	

Technology Areas *(cont.)*

└ TX03.1.1 Photovoltaic

Target Destination

Others Inside the Solar System